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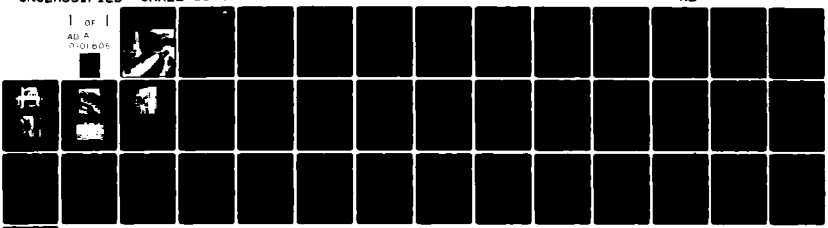

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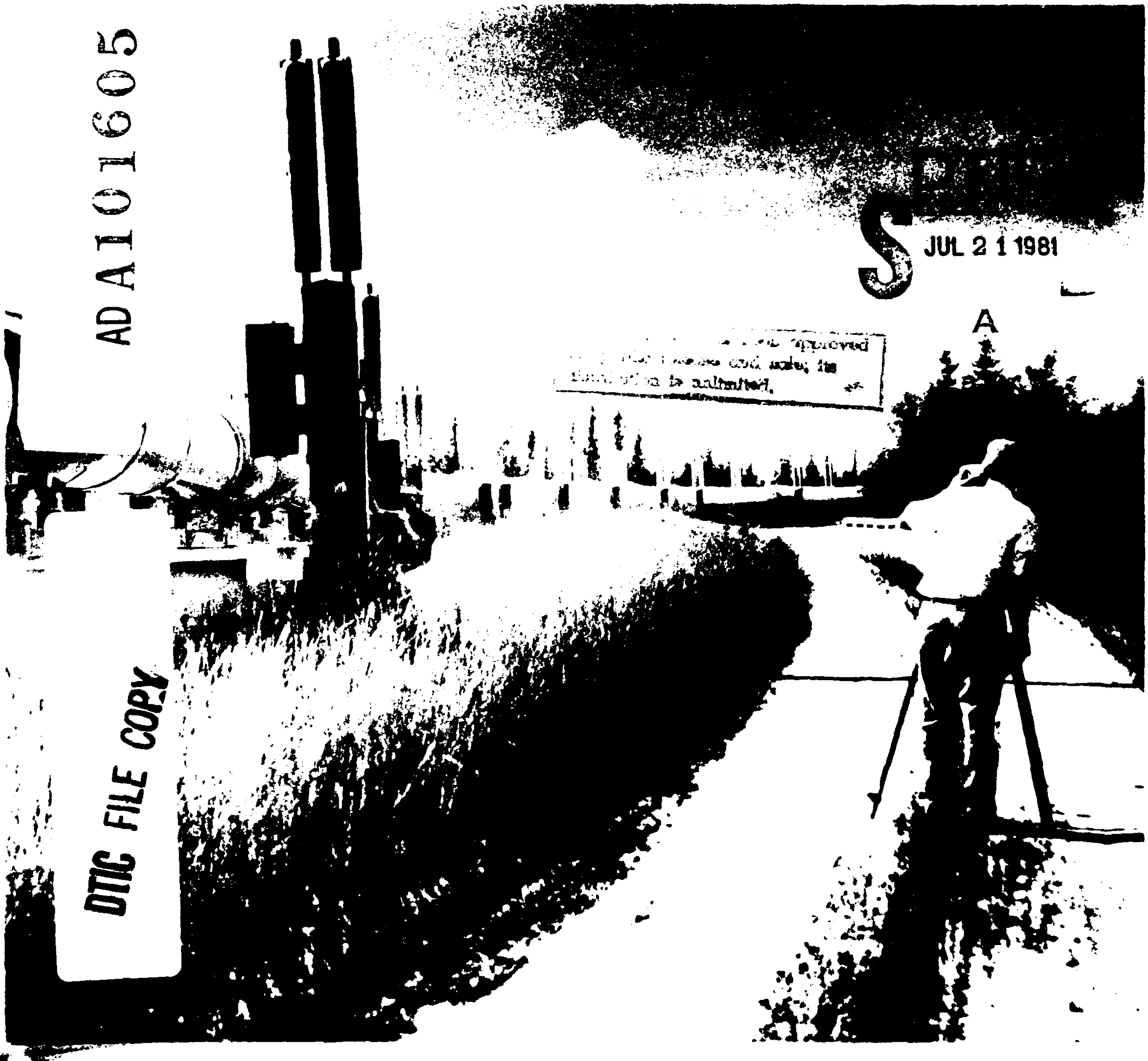

CRREL Report 81-4

Movement study of the trans-Alaska pipeline at selected sites

H.T. Ueda, D.E. Garfield and F.D. Haynes

April 1981

Prepared for
USA FACILITIES ENGINEER SUPPORT AGENCY
By
UNITED STATES ARMY
CORPS OF ENGINEERS
COLD REGIONS RESEARCH AND ENGINEERING LABORATORY
HANOVER, NEW HAMPSHIRE, U.S.A.

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: CRREL Report 81-4	2. GOVT ACCESSION NO.: AD-A101 605
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): MOVEMENT STUDY OF THE TRANS-ALASKA PIPELINE AT SELECTED SITES	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): H.T. Ueda, D.E. Garfield and F.D. Haynes	8. CONTRACT OR GRANT NUMBER(s): FESA Order No. 48009
9. PERFORMING ORGANIZATION NAME AND ADDRESS: U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire 03755	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: USA Facilities Engineer Support Agency, Ft. Belvoir, Virginia	12. REPORT DATE: April 1981
	13. NUMBER OF PAGES: 40
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Motion
Pipeline movement
Pipelines
Stability
Trans-Alaska Pipeline

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Eight sites along the trans-Alaska pipeline from the Denali Fault to Fairbanks were selected for pipeline and pipeline support movement studies. Four measurement surveys were conducted, starting before oil pumping operations began up to September 1978, to determine the lateral and longitudinal pipe movement due to the thermal expansion of elevated sections of the pipeline, the tilt of the vertical support members (VSM's), and the changes in relative elevation of the support crossbeams. A maximum lateral and longitudinal motion of the pipe of $13^3/_8$ in. and $2^{13}/_{16}$ in. respectively were measured up to September 1978. Tilt data for 180 VSM's showed little change over a one-year period, with only 5 VSM's tilting more than 0.5°. Relative elevation measurements showed insignificant changes for two sites

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20. Abstract (cont'd).

compared over a one-year period. Comparisons of our data with as-built elevations at 8 sites show a few large differences that cannot be readily explained. In general the pipeline and its supports, at least at the sites studied, show minimal movement and activity.

PREFACE

This study was conducted by H.T. Ueda and D.E. Garfield, Mechanical Engineers, Engineering and Measurement Services Branch, Technical Services Division, and F.D. Haynes, Materials Research Engineer, Ice Engineering Research Branch, Experimental Engineering Division, U.S. Army Cold Regions Research and Engineering Laboratory.

The study was funded under USA Facilities Engineer Support Agency Order No. 48009, *Trans-Alaska Pipeline Research Support;* Work Unit, *Terminals and Pump Stations.*

The writers wish to thank W.M. Witten, Vice President of Operations, Alyeska Pipeline Service Company for providing drawings of the pipeline sections studied; H.A. Deering and A. Gidney for their assistance in obtaining the field data; and F.E. Crory for his guidance.

F.E. Crory and F.H. Sayles of CRREL reviewed this report.

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CONVERSION FACTORS: U.S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

Multiply	*By*	*To obtain*
inch	25.4*	millimeter
foot	0.3048*	meter
mile	1,609.344*	kilometer
barrel (42 gal.)	0.1589873	$meter^3$
degrees Fahrenheit	$t_{°C} = (t_{°F} - 32)/1.8$	degrees Celsius

*Exact

MOVEMENT STUDY OF THE TRANS-ALASKA PIPELINE AT SELECTED SITES

H.T. Ueda, D.E. Garfield and F.D. Haynes

INTRODUCTION

One of the unique problems encountered in the construction of the Trans-Alaska Pipeline was the extreme temperature differential that could exist between the warm oil and the frigid ambient environment. This differential causes considerable expansion and contraction of the pipeline. The construction technique employed to compensate for this action is described in the following excerpt and Figure 1 which are from *Data sheet no. 8, zigzag configuration* (Alyeska *Pipeline Service Co. 1976*):

> Above-ground sections of the trans-Alaska pipeline are built in a unique zigzag configuration to allow for expansion or contraction of the pipe because of temperature changes. The design also allows for any motion caused by an earthquake. Approximately 400 miles of the 800 mile line are built above ground. Most of the remainder is buried conventionally.
>
> The 48 inch steel pipe above ground may be subjected to maximum temperature changes of about 215 degrees Fahrenheit. Pipe temperatures can range from a minus 70 degrees Fahrenheit (when empty of oil in midwinter) to 145 degrees Fahrenheit when filled with oil at the maximum pumping rate of 2 million barrels a day. Over this temperature range, the pipe expands more than 23 inches in a typical 1200-foot above-ground section. Above-ground sections, secured between fixed *anchor installations*, range from 700 to 1800 feet in length.
>
> To allow for the expansion or contraction (pipe installed in summer will contract in winter until oil is pumped through it) the pipeline is built in trapezoidal sections which convert changes in pipe length to sideways movement. In this pattern, thermal growth deforms the pipe between the fixed anchors, changing the normal trapezoid into a gentle "S" curve.
>
> The design permits a maximum of 96 inches of such sideways *movement* because of heat and a maximum of 50 inches lateral movement in the opposite direction for *contraction* because of cold. Another 24 inches of lateral motion is provided for in the event of an earthquake.
>
> To permit the sideways motion, the pipe is mounted so it can move on crossbeams installed between vertical supports placed in the ground. The crossbeams vary *in length* depending on the sideways motion predicted at each point. The pipe is positioned off center on the beams to permit maximum expected hot, cold and dynamic movements.
>
> At points where the above-ground line drops below ground, a special transition configuration allows up to 18 inches of thermal growth of pipe coming from the ground, in *addition* to expansion of the pipe above ground. Four bends in this configuration, rather than two, permit the additional thermal movement to occur without placing unacceptable stresses on the pipe.

During the period June 1977 to September 1978, four measurement surveys were conducted on the pipe and pipe-supporting crossbeams at several sites along the Trans-Alaska Pipeline. These measurements included the lateral and longitudinal displacement of the pipe shoe on the support platform, the tilt of the vertical support members (VSMs), and the relative elevation of the pipe support crossbeams. The location of the measurements made at each support are shown in Figure 2.

Twelve sites were originally selected to be surveyed. They were chosen to represent a varied set of conditions that might cause pipe movement such as slope of the terrain, proximity to a pump station and potential earthquake zones. Ultimately only seven sites proved to be accessible for the four surveys conducted. Due to operational difficulties such as inclement weather and pipeline security, all of the desired measurements could not be made during each survey at each of the seven sites. One additional site was added in September 1978. Figures 3 and 4a–e show the locations and give our designation for each site. Milepost (MP) figures are pipeline distances from Pump Station no. 1.

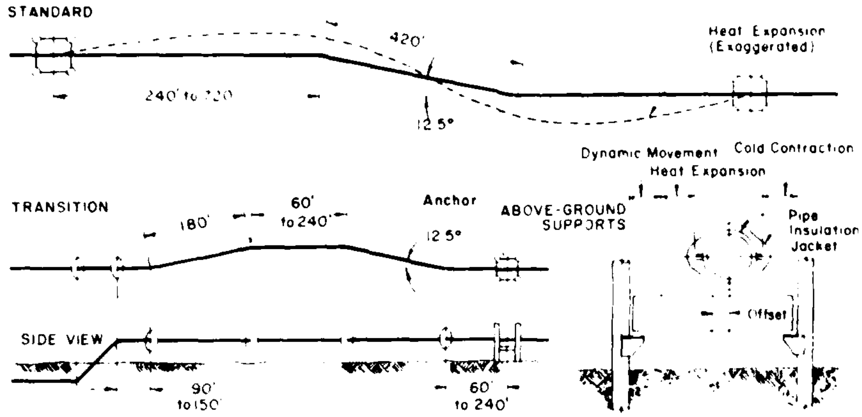


Figure 1. Pipeline design for expansion and contraction (from Alyeska Pipeline Service Co. 1976).

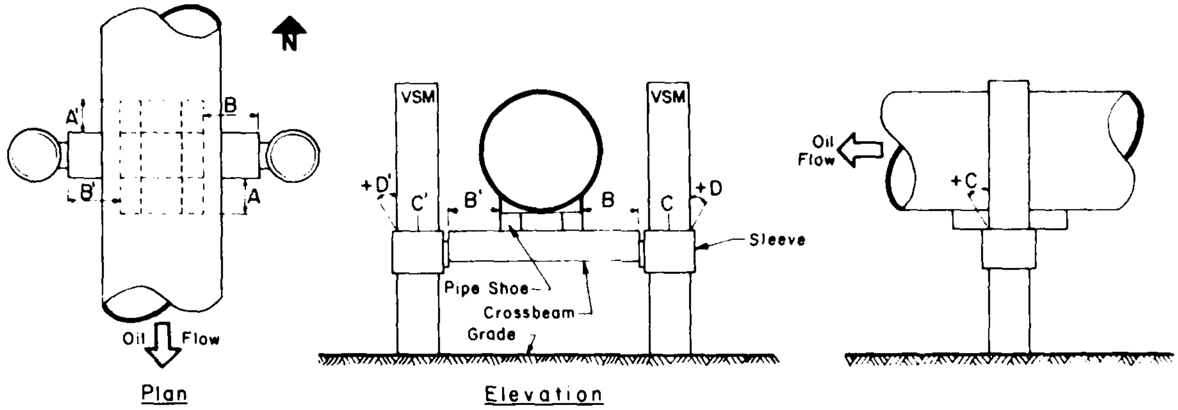


Figure 2. Typical measurements made at each support (A,A', B,B' — measurements of pipe shoe position. C,C', D,D' — tilt measurements).

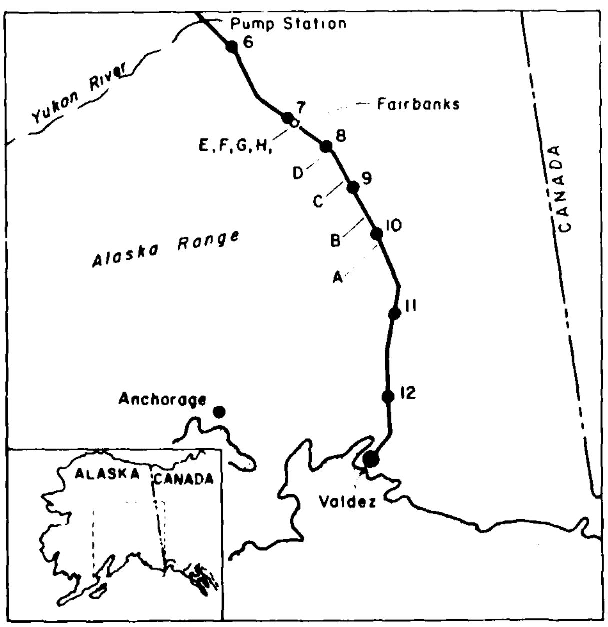
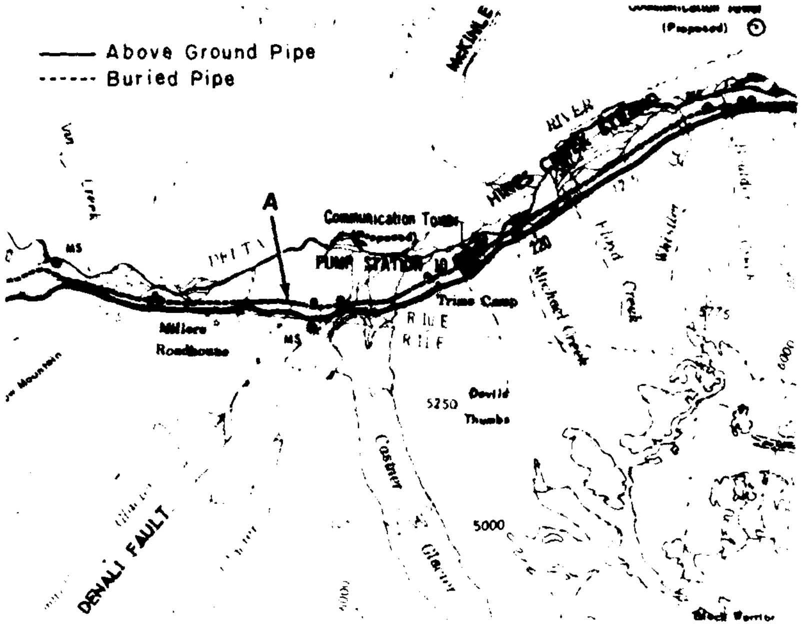
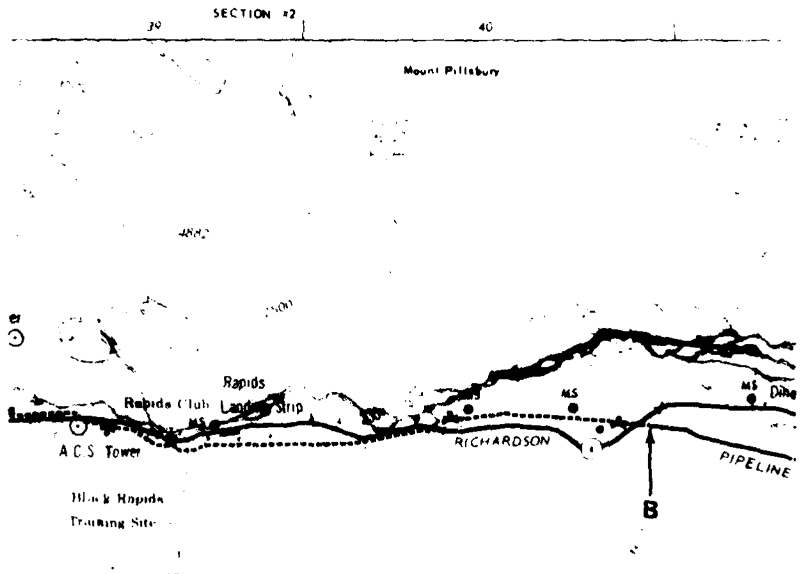


Figure 3. Approximate site locations.

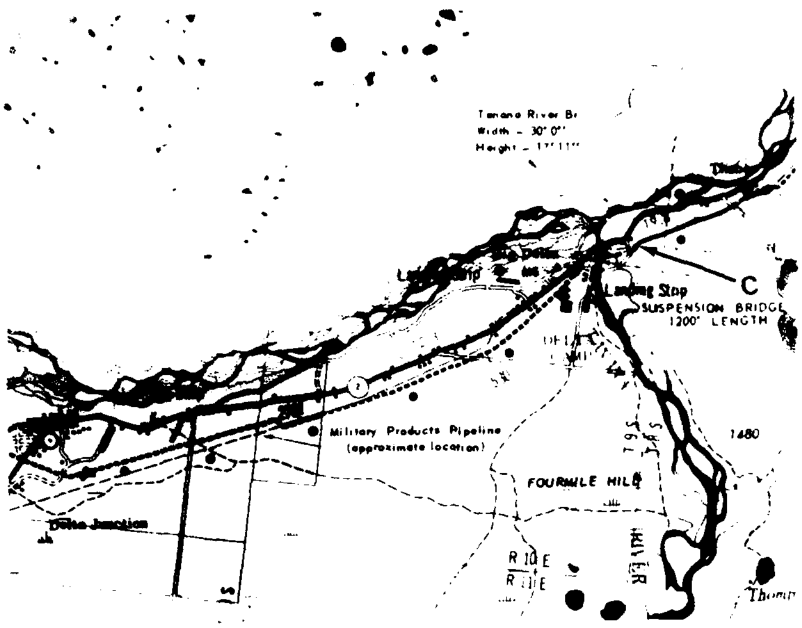


a. Site A, MP-587, over Denali Fault.

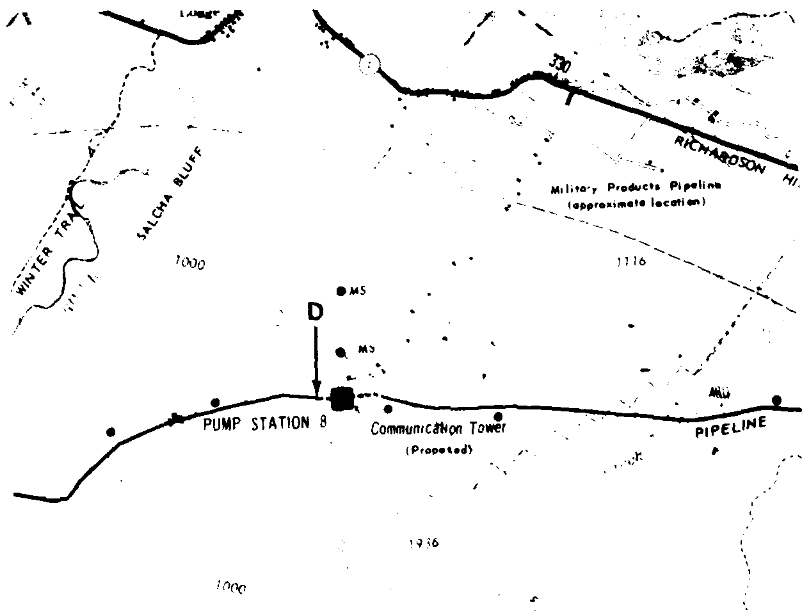


b. Site B, the section where pipeline emerges from the ground after crossing the Richardson Highway, approximately 1000 ft north of MP-569.

Figure 4. Site locations.

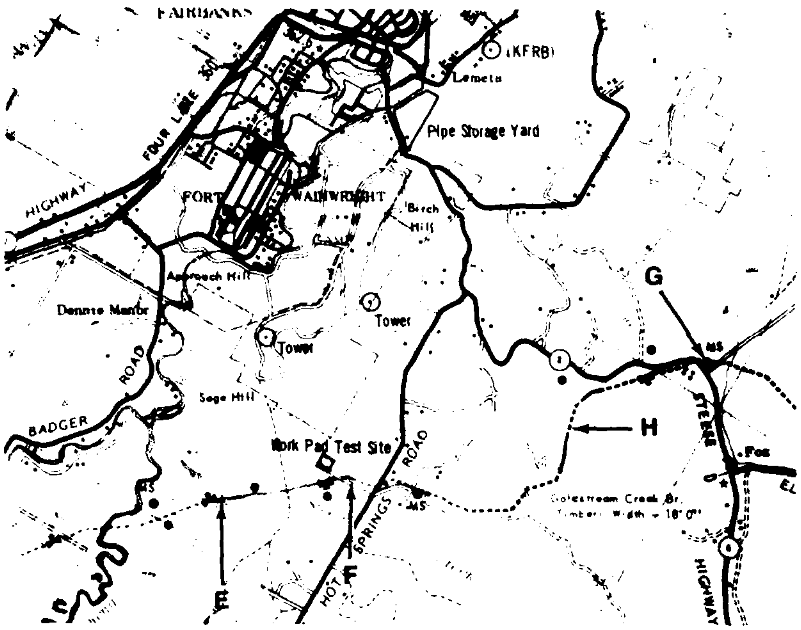


c. Site C, the section where pipeline emerges from the ground, approximately 3000 ft north of Tanana River.



d. Site D, the section immediately south of Pump Station no. 8 where the pipeline emerges from the ground.

Figure 4. Site locations (cont'd).



e. Site E, the section where the pipeline emerges from the ground, approximately 3000 ft south of MP-456. Site F, the section immediately south of the Chena Hot Springs Road where the pipeline emerges from the ground at approximately MP-456. Site G, the section of the pipeline from the Steese Highway to Goldstream Creek. Site H, the section immediately north of MP-450

Figure 4. (Cont'd).

The first survey was made in June 1977, prior to the initial flow of oil. The second survey was made in September 1977 when the oil was flowing at approximately 300,000 barrels per day. A partial survey was conducted in early April 1978 when the flow was 1,200,000 barrels per day (Alaska Construction and Oil 1979). A final survey was conducted in September 1978 approximately one year after the initial flow of oil.

MEASUREMENT TECHNIQUE

Pipeline movement

Four measurements representing the positions of the pipe shoe on its support platform were made at each support. They are indicated in Figure 2 as A,A', and B,B'. The primed letters denote measurements made on the opposite sides of the crossbeam and pipe, respectively. By taking two opposite measurements it was possible to determine from two surveys the lateral and longitudinal movement and/or the horizontal rotation of the pipe shoe. In addition, from two or more surveys, any gross reading errors could be detected because the sum of opposite readings should be approximately equal. A conventional tape rule was used and readings were taken to the nearest $\frac{1}{16}$ in. (Fig. 5 and 6). Opposite readings were not taken on the special beam supports used at the Denali Fault, due to the extreme length (55 ft) of the supports (Fig. 7). Therefore, the horizontal rotations of the pipe shoes at this site could not be determined.

A total of 155 supports at eight sites were measured. The length of pipe covered at a given measurement site normally extended between two or more pipeline anchor points or between an anchor and the point at which the pipeline entered the ground. Lateral or longitudinal movement of the pipe at an anchor should, by design, be minimal. One measurement was made at each anchor to determine any longitudinal pipe motion. A typical anchor is shown in Figure 8.

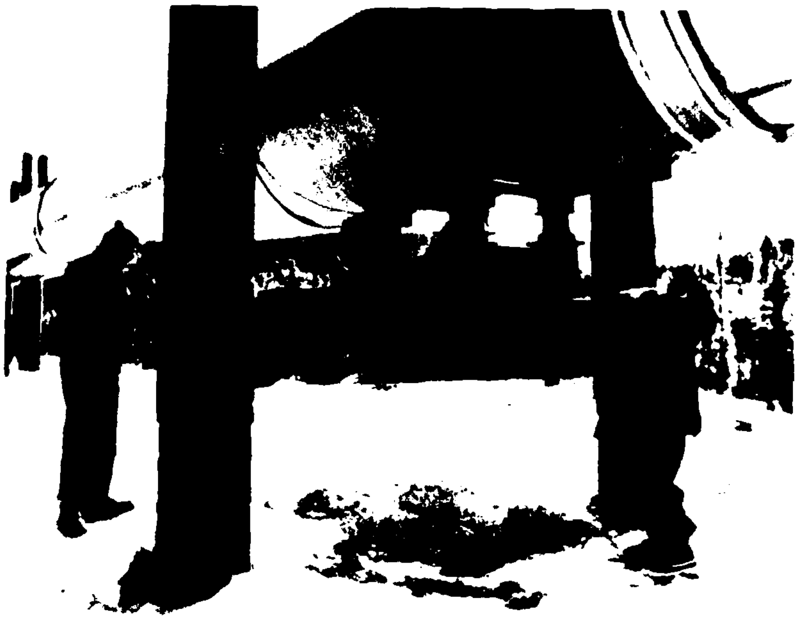


Figure 5. Measuring longitudinal position of pipe shoe.

Figure 6. Measuring lateral position of pipe shoe.

Figure 7. Special beam supports used at Denali Fault section of pipeline.

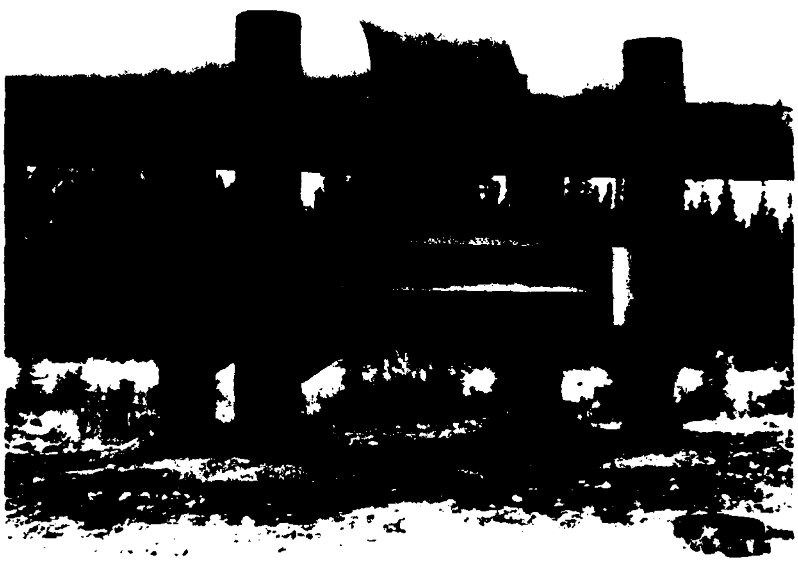


Figure 8. Typical pipeline anchor.

Figure 9. Typical level rod station on top of support sleeve.

Vertical support member tilt

Tilt or vertical deviation measurements were made on each vertical support member (VSM) in directions perpendicular and parallel to the pipeline. These are indicated as C,C' and D,D' in Figure 2. The primed letters denote the measurement made on the VSM on the opposite side of the crossbeam. Initially a relatively simple device with a resolution of about 0.5° was employed to measure the tilt, but it proved to be inadequate. Later an electronic, digital-readout instrument was designed with a resolution of 0.01° and was used successfully. The heart of the instrument was a Schaevitz Model LSOC servo inclinometer with a range of ±14.5°. Positive readings indicate an outward inclination when measuring in position D or D' or a downstream (relative to oil flow) inclination when measuring in position C or C'.

Relative elevations of pipe support crossbeams

Relative elevations were measured with a Wilde T-3, self-leveling level. Readings were taken from the tops of the sleeves that were rigidly attached to the ends of each support crossbeam (Fig. 9). The two readings were averaged to obtain the crossbeam elevation. At the Denali Fault site, the readings were taken from the top surface at each end of the special beam supports.

The usual procedure was to start at one leg of an anchor or support, proceed down one side of the line of supports, reading the level of each VSM sleeve on that side, then return on the opposite side following the same procedure, and finally close the loop on the original station. Readings were made to the closest 0.01 ft.

None of the elevations were compared to a fixed benchmark. Elevations for a given site were compared to a reference support, usually the last support next to an anchor at the end of the site.

RESULTS AND DISCUSSION

Pipeline movement

The maximum lateral and longitudinal movements measured were 13$\frac{5}{8}$ in. and 2$\frac{11}{16}$ in. respec-

tively. As expected, the motion at the anchors was minimal, with a maximum longitudinal movement of $\frac{5}{16}$ in.

The lateral, longitudinal and horizontal rotational movements of the pipe are shown in Appendix A (Fig. A1 through A7). The movements indicated are for the period June 1977 to September 1978. No movements can be shown for site H (Fig. A8) since only one set of measurements were made at this site. The maximum lateral displacement is noted for each site. It represents the average of measurement B and B'. Except at site A, the maximum displacements occur within the trapezoidal sections which were built in for this purpose. The movements of all supports for all the surveys are tabulated in Table B1. The support identification numbers used are those numbers which are stenciled on each crossbeam.

Most of the measurements indicate a progressively increasing or decreasing movement of the pipeline. There is little evidence of any cyclic action although it could have occurred during the period between our surveys. The initial and early movements which occurred at the start of oil flow were detected in our September 1977 survey. An increase in oil temperature created by an increase in the flow to 1,200,000 barrels per day in March 1978 resulted in further movement that was detected in the April 1978 survey. The final movement noticed in our September 1978 survey was probably due to the combination of warm oil and warm ambient temperatures. The final displacements measured in September 1978 should be approximately the maximum pipeline displacement expected for the flow of 1,200,000 barrels/day. Further movement can be expected when the projected flow of 2,000,000 barrels/day is attained.

Thus far the lateral motion of the pipeline appears to be well within design limits. There were a few locations where the insulating cocoon around the pipe was near or touching the VSM. However, none of these appeared to be creating a serious problem at this time, such as excessive lateral loading of the VSM.

Vertical support member tilt

In September 1978 a total of 312 VSMs at eight sites were measured for tilt. Of this total, 69 had a tilt equal to or greater than 0.5°, with 37 of these located at site G. Twelve had a tilt greater than 1.0° with 10 of these also located at site G.

Tilt data were compared for 180 VSMs from five sites (A, B, C, F and G) over the period September 1977 to September 1978. This was the period during which the electronic level was used. Only five VSMs showed a change in tilt greater than 0.5°. The greatest change detected was 1.09° perpendicular to the pipeline. Four of the five, including the worst change, were located at site G near Goldstream Creek. The soil conditions plus the high water table at site G have apparently combined to create a relatively unstable condition.

Measured tilts and changes in tilt are tabulated in Table B2. The single set of measurements for site D and site E are also included.

Relative elevations

The elevation surveys were conducted to measure any changes in relative elevation of the pipeline support crossbeams. These changes in relative elevation would result from differential vertical movement of the VSMs within a given site. Due to operational problems, only two sites, sites A and B, could be surveyed in September 1977. In September 1978, eight sites, including A and B, were surveyed. In addition to comparing the data from sites A and B for the one-year period, the data from all of the sites were compared to as-built elevations which were taken from drawings obtained through the cooperation of the Alyeska Pipeline Service Company.

Site A at the Denali Fault commands particular interest due to the high potential there for seismic activity. The pipeline at this location is supported on special steel and concrete beams (Fig. 7) which are placed on a gravel berm built over the natural ground (Alyeska Pipeline Service Co. 1973).

The one-year comparison shows very little relative movement. A maximum movement of 0.06 ft occurred at two supports at site A. They are support no. 13 and support no. 11A1754, both relative to support no. 33A3409 located at the south end of the section. Two other supports showed a movement of 0.05 ft and four showed a movement of 0.04 ft. All movements were negative relative to support no. 33A3409. Within the accuracy of the survey, the remaining supports showed essentially no relative movement.

Site B supports moved even less. The greatest change detected was 0.04 ft at one support over the one-year period. The remaining supports showed essentially no movement, at least relative to support no. 15A1649.

By converting the elevations obtained from

the as-built drawings to relative elevations in the same manner as in our analysis, a comparison was made for the approximately two- to three-year period preceding September 1978. The elevation differences for most of the survey appear to be reasonable. However, there are some obvious discrepancies.

At site A, data indicated an almost 2-ft elevation change for support 62A178 relative to support 33A3409. At sites B, C, D, E, F and H, there is at least one support at each site which appears to have changed elevation from 0.24 ft to 0.53 ft. At site G there is one support that showed a 0.59-ft movement and another with a 2.89-ft movement. Possible explanations for the larger variations noted are: 1) some significant changes did occur in support movement and were rectified, 2) the actual as-built elevations did not conform with the drawings, or 3) there was an error in the readings. If such large movement did take place it was certainly not evident in our observations.

All level survey data are presented in Table B3. Also noted are the estimated accuracies of each survey. The reference support for each site is indicated in Figures A1–A8.

SUMMARY

Measurements made over several selected sites along the Trans-Alaska Pipeline indicate that the pipe is moving well within design limits and the pipe supports are showing a minimal amount of activity. Since the flow of oil began in late July 1977 through a period ending in September 1978, a gradual increase in movement in the same direction has been measured. This corresponds to a gradual increase in flow to a maximum of 1,200,000 barrels/day in March 1978 and a combination of flow and ambient temperatures accounting for the final increment of movement. The measured movements should be close to the maximum movements expected for an oil flow of 1,200,000 barrels/day.

The tilt and elevation data have revealed that most of the vertical support members observed are stable. Site G near Goldstream Creek, with the highest number of VSM tilts over 1°, undoubtedly possesses poor soil conditions. This and a high water table have apparently helped produce the least stable site of those we surveyed.

The Denali Fault section of the pipeline appears to be performing well. No significant movement of the special supports or the pipe itself are evident. One conventional support showed a nearly 2-ft vertical movement when compared with the as-built elevation but our observations did not reveal any motion even approaching this magnitude.

This study has been completed. The data should prove useful for similar future investigations. It is suggested that a measurement program be conducted at five-year intervals to detect any long term longitudinal and lateral movement of the pipe and vertical displacement of the VSMs at these sites.

A separate study by Crory (pers. comm.) includes some of the same measurements made at site A and site H in this report in addition to measurements from sites further north. He has also included temperature observations made on the pipe and in the foundation material.

LITERATURE CITED

Alaska Construction and Oil (1979) Chronology of pipeline events. Vol. 20, no. 8, Aug.

Alyeska Pipeline Service Company (1973) Trans-Alaska Pipeline System, 48-in. oil pipeline, Denali Fault interior supports on gravel berm. Dwg. No. D-00-C243, sheet 1 of 1, Oct.

Alyeska Pipeline Service Company (1976) Data sheet No. 8, zigzag configuration, February 1976.

APPENDIX A: LATERAL, LONGITUDINAL AND HORIZONTAL PIPE MOVEMENT IN EXAGGERATED SCALE
(June 1977 to September 1978)

Plan view (top): Arrows that show lateral movement are proportional to the maximum value of lateral movement; dot represents movement of ½ in. or less; arrows that show longitudinal movement show direction only; curved arrow shows horizontal rotation.
Elevation chart (bottom): Horizontal scale in 200-ft intervals.

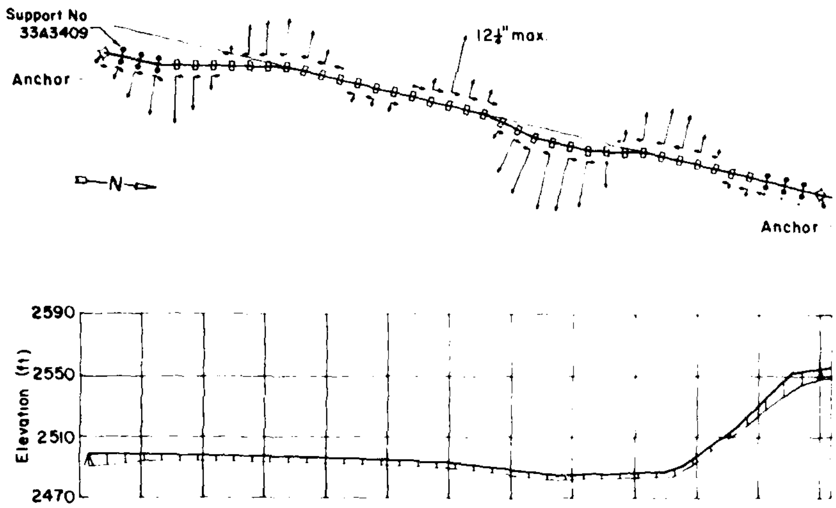


Figure A1. Site A.

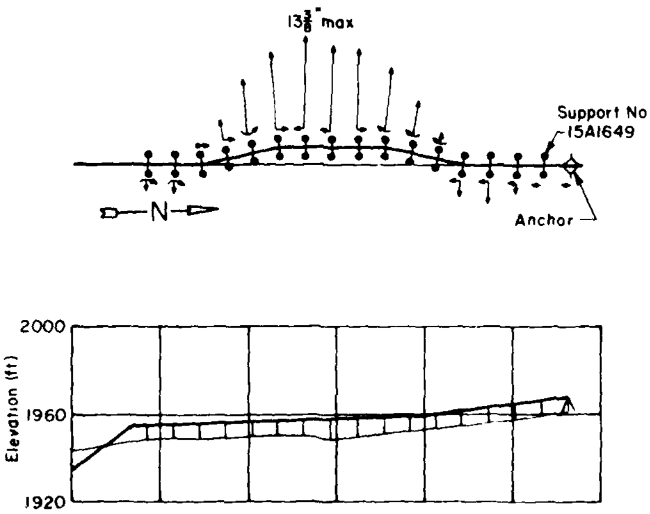


Figure A2. Site B.

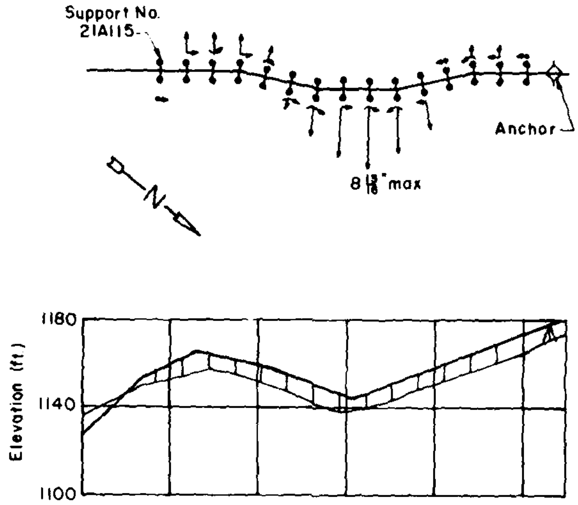


Figure A3. Site C.

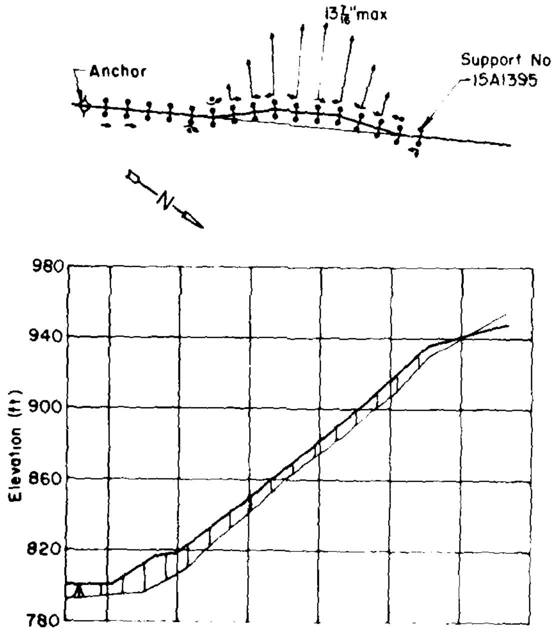


Figure A4. Site D.

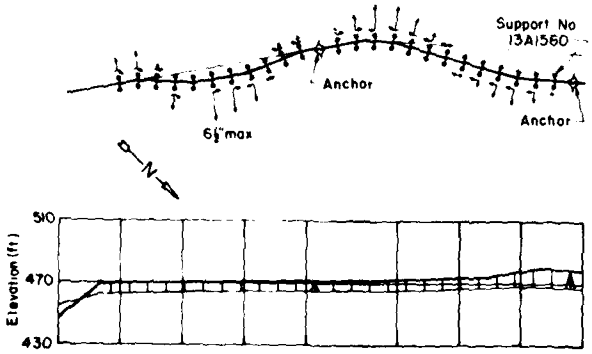


Figure A5. Site E.

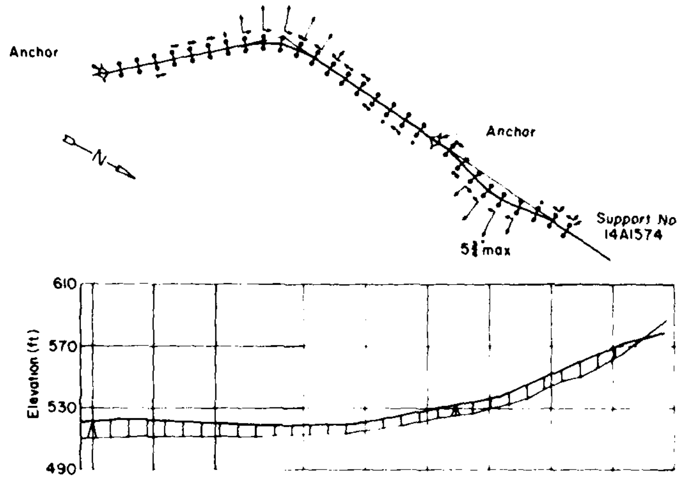


Figure A6. Site F.

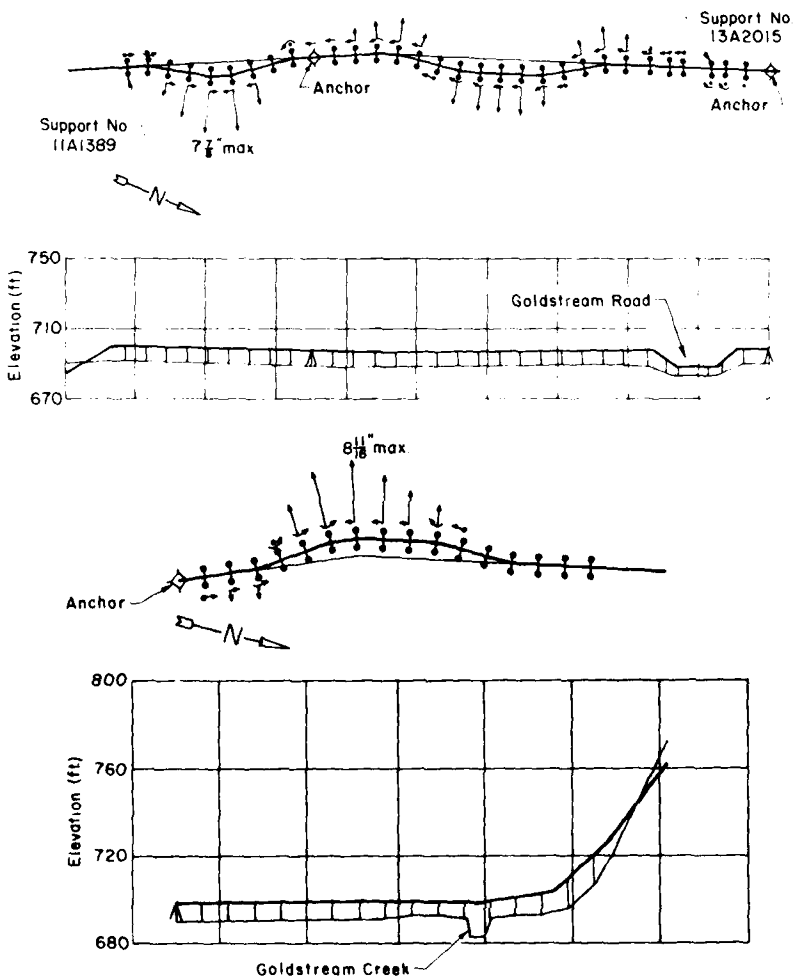


Figure A7. Site G.

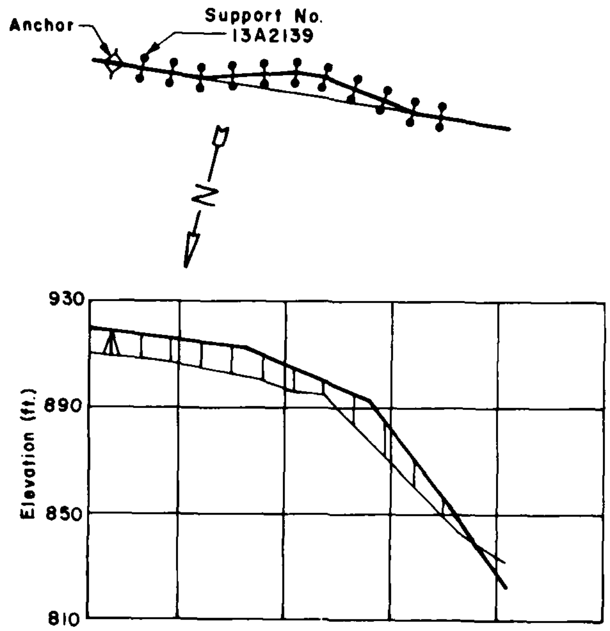


Figure A8. Site H.

APPENDIX B: TABULATION OF MOVEMENT MEASUREMENTS

Table B1. Pipeline longitudinal and lateral movement.

Δ = change in position since June 1977.

First row: ΔA, ΔB — Except at anchors and special beam supports at site A.

Second row: ΔA', ΔB'

Support no.	ΔA, ΔA' (in.) Sept 1977	ΔA, ΔA' (in.) Mar 1978	ΔA, ΔA' (in.) Sept 1978	ΔB, ΔB' (in.) Sept 1977	ΔB, ΔB' (in.) Mar 1978	ΔB, ΔB' (in.) Sept 1978
			Site A			
Anchor	1/16		3/16			
33A3409	-1/8		-7/16	-15/16		-2 1/4
	3/8		3/4	13/16		2 5/16
7B141	-1/16		-11/16	-2 11/16		-5 11/16
	3/8		13/16	2 5/8		5 5/8
82A46	3/8		3/4	-4 3/16		-7 15/16
	-5/16		-7/16	4		7 7/8
5	-3/4		-1 5/8	-3 3/4		-9 7/16
6	-3/4		-1 5/8	-2 3/8		-6 1/2
7	0		-1/16	-3/4		-2 3/8
8	0		11/16	0		1
9	1/8		1 7/8	1 3/8		4 5/8
10	7/8		2 13/16*	3 1/8		7 1/16
11	1/2		1	4		7 3/8
12	3/8		3/4	2 5/8		5 1/2
13	3/8		5/8	1 5/8		2 13/16
14	0		1/4	1/8		1/8
15	-1/4		1/16	0		-1 3/8
16	-1/8		1/16	1/8		-1 1/2
17	0		-5/16	-1/8		-1 7/16
18	-1/4		-3/4	0		0
19	-3/8		-7/8	3/4		2 5/16
20	-5/8		-1 1/8	1 3/4		12 1/4*
21	-1/2		-1 3/8	2 1/4		4 1/4
22	-3/4		-1 1/2	1 7/8		2 1/2
23	-3/8		-15/16	1/2		1 3/16
24	-3/8		-1 1/16	-2		-6 1/2
25	1/8		3/8	-3 5/8		-9 7/8
26	1/4		5/16	-4 1/8		-11 5/8
27	0		-1/8	-3 3/8		-11
28	-1/4		-3/8	-2 7/8		-9
29	0		0	-7/8		-3 5/8
30	7/8		2 3/8	1 3/8		1 3/4
31	7/8		2 1/16	3 1/8		5 3/4
32	3/4		2	3 1/2		7 5/16
33	5/8		1 11/16	2 7/8		6 7/16
34	1 3/8		2 3/8	1 1/4		4 1/16
35	5/8		1 1/2	1/2		1 1/4
36	1/2		1 1/4	0		-7/8
37	-1/4		5/8	1/4		-7/16
6[illegible]A178	0		1/8	-1/16		0
	0		1/16	1/16		0
24A920	-1/16		0	0		0
	0		0	1/16		1/16
11A1754	1/16		0	1/8		1/16
	1/16		0	0		0
Anchor	1/8		1/16			

Table B1. (Cont'd).

Support no.	ΔA, ΔA' (in.) Sept 1977	Mar 1978	Sept 1978	ΔB, ΔB' (in.) Sept 1977	Mar 1978	Sept 1978
Site B						
22A90	-9/16	-3/16	-1 1/8	-7/16	5/8	-7/8
	11/16	1 3/16	1 5/16	1/2	3/4	1
22A91	-7/8	-1	-1 5/8	-5/8	-1	-1 1/4
	15/16	1 3/8	1 13/16	5/8	1 1/4	1 5/16
23A193	-3/4	-1 1/8	-1 7/8	-1/16	-3/16	5/16
	15/16	1 7/16	1 3/4	1/4	5/16	-1/4
23A195	-11/16	-1 3/16	-1 11/16	1 7/16	2 1/16	3
	5/8	1	1 9/16	-1 7/16	-2 1/16	-3 1/16
43A0389	-1 1/8	-1 11/16	-2 1/4*	4 1/8	5 3/4	8
	1/16	9/16	1 1/8	-4 3/16	-5 13/16	-8 1/16
63B9	-7/8	-1 3/16	-2 1/16	6	8 3/16	11 11/16
	1	1 1/2	2	-5 7/8	-8 1/8	-11 5/8
71A0265	1/4	1/8	5/16	6 5/16	9 1/4	13 1/2*
	-1/8	-1/8	-1/4	-6 1/8	-9 1/16	-13 1/4
71B0889	5/16	3/8	1/4	5 3/16	8 3/16	12 5/16
	-3/16	-1/4	-1/4	-5 3/16	-8 1/16	-12 1/4
73A0448	1/16	0	-1/8	4 3/16	7 5/16	10 7/8
	0	1/8	1/8	-4 1/8	-7 5/16	-10 13/16
62B5	1/2	1	1 1/2	2 7/8	6 7/16	8 11/16
	-7/16	-1 1/16	-1 5/16	-2 3/4	-6 1/4	-8 1/2
44A0460	7/16	1 1/16	1 5/16	1 3/16	4 3/16	4 15/16
	-1/4	-13/16	-1	-1 1/8	-4 3/16	-4 7/8
23A194	3/8	7/8	1 1/8	-1/4	7/8	5/8
	-5/16	-11/16	-15/16	3/8	-3/4	-1/2
15A1618	1/8	1/2	9/16	-1 1/4	-1 1/4	-1 3/4
	-3/16	-9/16	-3/4	1 1/4	1 3/8	1 13/16
25A93	7/16	3/4	1	-15/16	-1 7/8	-2 5/16
	-9/16	-3/4	-1 1/8	15/16	1 7/8	2 5/16
25A142	5/16	3/4	1	-3/16	-9/16	-1 1/8
	-5/16	-3/4	-1	3/16	7/8	1 3/16
15A1649	1/16	3/16	3/16	0	0	0
	-1/8	-3/16	-1/4	0	0	1/16
Anchor	1/8		-3/16			
Site C						
21A115	-1/4	-1/2	-11/16	-1/16	-1/16	-1/8
	3/8	3/8	3/4	1/8	1/8	3/16
25A149	-5/16	-5/8	-1	3/8	1/2	1 5/8
	3/8	9/16	15/16	-3/8	-1/2	-1 11/16
25A151	-1/2	-7/8	-1 3/16	1 3/16	2 5/8	3 5/16
	1/2	7/8	11/16	-1 1/8	-2 11/16	-3 5/16
25A150	-3/8	-3/8	-5/8	15/16	3 5/16	3
	3/8	5/16	3/4	-7/8	-3 5/16	-3
25A152	-5/16	-1/8	-9/16	1	2 1/2	2 3/16
	5/16	5/16	13/16	-15/16	-2 3/8	-2
44A0446	-3/16	-1/4	-3/4	-1/8	-1/8	-1
	1/4	3/8	+15/16	1/4	9/16	1 3/16
62B3	-7/16	-13/16	-1 1/8	-1 3/8	-3 3/16	-4 13/16
	1/2	3/4	1 7/16*	1 5/16	2 13/16	4 15/16
72B0130	-3/16	-1/4	-3/16	-1 7/8	-3 9/16	-7 9/16
	3/16	3/16	1/4	2 1/8	3 13/16	7 13/16
74A0099	-1/4	-7/16	-5/8	-2 1/8	-4 7/16	-8 3/4
	1/4	1/2	7/8	2 1/4	4 1/2	8 15/16*
72B0132	1/16	7/16	13/16	-1 13/16	-4 5/8	-7 1/4
	-3/16	-7/16	-1 1/16	2	4 3/4	7 5/16

Table B1. (Cont'd).

Support no.	ΔA, ΔA' (in.) Sept 1977	Mar 1978	Sept 1978	ΔB, ΔB' (in.) Sept 1977	Mar 1978	Sept 1978
55A57	1/8	-1/4	7/8	-1 1/16	3	-4 1/16
	-1/16	3/8	-13/16	1 1/8	-3 1/16	4 1/16
21A113	1/8	1/8	5/16	1/16	0	3/16
	-1/16	-1/4	-3/8	0	-3/16	-1/4
11A129	1/8	1/4	5/8	3/16	1 1/8	1 1/16
	-1/16	-1/2	-13/16	-1/4	-1 5/16	-1 3/16
12A166	1/4	5/8	3/4	1/2	1 1/2	1 11/16
	-3/16	-7/16	-11/16	-3/8	-1 3/8	-1 9/16
12A168	-1/16	1/16	3/8	0	0	7/16
	-1/8	0	-9/16	1/8	1/16	-9/16
Anchor	1/8		0			
			Site D			
Anchor						
14A1701			1/8			0
			3/16			-1/16
13A1739			-1/4			0
			3/8			-1/16
13A1871						
23A1170						
24A757			-3/4			-5/16
			15/16			5/16
24A726			-1 7/16			9/16
			1 1/8			-1/2
24A798			-1 3/16			3 1/16
			1 5/16			-3 3/16
35A3489			-1 15/16			6 3/4
			1 3/4			-6 15/16
52B126			3/16			11
			-3/16			-10 1/16
61B81			3/8			12 15/16
			-7/16			-13
73B0692			-3/16			13 5/8*
			1/2			-13 1/4
52B125			2 13/16*			12 1/8
			-2 11/16			-12 1/16
66A317			2 7/16			8 1/16
			-2 1/8			-7 7/8
24A797			2			4 1/16
			-1 15/16			-3 13/16
13A1872			1 11/16			9/16
			-1 11/16			-3/8
15A1395			1 5/8			-7/8
			-1 9/16			15/16
54B196						
			Site E			
16A1393			-1 1/16			2 9/16
			1 1/2			-2 9/16
16A1396			-11/16			3 1/2
			1 1/16			-3 7/16
25A861			-7/8			1 1/4
			15/16			-1 1/16
52A209			-15/16			-2 5/8
			1 3/16			2 13/16

Table B1. (Cont'd).

Support no.	ΔA, ΔA' (in.) Sept 1977	Mar 1978	Sept 1978	ΔB, ΔB' (in.) Sept 1977	Mar 1978	Sept 1978
76B0868						
76B0867			1/16			-6 9/16*
			1/16			6 1/2
74A0880			-1/4			-5 1/2
			3/16			5 1/2
73B0850			3/16			-3 5/8
			-3/16			3 3/4
52A214			3/16			-9/16
			-1/8			9/16
34A2899			0			13/16
			1/8			-3/4
16A1394			1/16			15/16
			3/16			-7/8
Anchor						
23A1238			-1/4			13/16
			1/4			-15/16
25A862			-1/4			3 1/16
			1/4			-3 3/16
43B2346			1/4			4 15/16
			-3/16			-5
42B0937			1 11/16*			5 3/16
			-15/16			-5 1/4
35A2920			1 7/16			3 3/4
			-1 1/8			-3 11/16
23A1237			7/8			1 7/16
			-1			-1 3/8
25A863			1/2			1/4
			-5/16			-1/4
11A1450			1/8			-1/2
			0			1/8
11A1452			5/16			-1
			-3/16			1 1/16
23A1240			1/16			-2 3/4
			1/16			2 13/16
24B72			11/16			-3 1/16
			-11/16			3 3/16
24B69			5/8			-2 7/16
			-9/16			2 5/16
13A1560			1/4			-5/16
			-5/16			5/16
Anchor			1/16			
			Site F			
14A1574	-3/16	-1/2	-11/16	-1/16	-1/16	-1/16
	1/16	3/8	5/16	1/16	1/16	1/16
16A1411	-5/16	-5/8	-7/8	1/8	0	1/16
	5/16	1/2	7/8	0	0	1/16
24B71	-9/16	-7/8	-1 1/4	1/4	1/16	1/16
	5/8	7/8	1 1/4	-3/16	-3/16	-1/8
21A696	-5/8	-1	-1 7/16	3/8	11/16	13/16
	5/8	1	1 1/4	-5/16	-11/16	-7/8
21A694	-13/16	-1 1/4	-1 3/8	3/4	1 3/8	1 15/16
	3/4	1 3/16	1 7/16	1/16	-1/2	-15/16
33B3585	-13/16	-1 1/2	-2 1/16*	1 3/4	2 3/4	3 15/16
	15/16	1 9/16	2	-1 13/16	-2 7/8	-4

Table B1. (Cont'd).

Support no.	ΔA, ΔA' (in.) Sept 1977	Mar 1978	Sept 1978	ΔB, ΔB' (in.) Sept 1977	Mar 1978	Sept 1978
33A2860	-9/16	-1 1/8	-1 7/16	2 5/16	4 3/16	5 3/16
	5/8	1 3/16	1 7/16	-2 5/16	-3 15/16	-5 3/16
43B0950	-5/16	-7/16	-11/16	2 9/16	4 5/8	5 5/16
	3/8	9/16	13/16	-2 1/2	-4 5/8	-5 1/4
33A2858	9/16	1 1/8	1 3/16	2 3/16	3 15/16	4 13/16
	0	-1/2	-7/8	-2 1/8	-3 7/8	-4 5/8
33B3591	5/8	1 1/8	1 1/2	1 7/16	2 1/2	3 9/16
	-1/2	-15/16	-1 3/8	-1 7/8	-2 1/2	-3 1/2
22A701	3/16	1 1/8	1 1/2	3/4	1 3/8	2
	-5/8	-15/16	-1 1/4	-11/16	-1 7/16	-1 7/8
21A693	7/16	11/16	1 1/16	5/16	3/8	3/8
	-3/8	-9/16	-15/16	-5/16	-3/8	-3/8
23B94	-1/4	5/8	13/16	3/16	1/8	1/8
	-1/4	-1/2	-11/16	-5/8	-9/16	-5/8
16A1412	1/8	1/4	7/16	0	-1/16	-1/16
	-3/16	-3/8	-9/16	3/16	1/16	1/8
16A1409	0	0	0	0	0	0
	1/16	1/16	1/16	1/16	1/16	1/16
16A1410	1/16	1/16	1/16	1/16	-1/16	-1/16
	0	0	-3/16	0	0	0
11A1494	1/16	1/16	1/16	0	0	0
	1/16	1/16	1/16	1/16	1/16	1/16
Anchor	-5/16		0			
11A1496	-1/16	-1/8	-3/16	1/8	3/16	1/4
	1/8	1/4	5/16	-1/16	-1/8	-1/4
21A695	-1/4	-9/16	-5/8	0	-1/4	-1/8
	3/8	11/16	3/4	0	1/8	1/8
33A2863	-3/16	-9/16	-3/4	-1 7/8	-2 1/2	-3 1/8
	7/16	13/16	1	1 15/16	2 1/2	2 15/16
53B221	1/2	3/16	9/16	-3	-4 1/8	-5 3/8
	-3/8	-1/16	-5/16	3	4	5 3/8
41B1248	1 1/4	1 3/16	1 3/4	-3 5/16	-4 1/4	-5 3/4
	-1 9/16	-1 1/16	-1 9/16	3 5/16	4 1/4	5 13/16*
31A2789	13/16	3/4	1 1/8	-1 15/16	-2 3/16	-3 1/2
	-15/16	-7/8	-1 5/16	1 15/16	2 1/8	3 9/16
22A702	0	0	0	0	0	0
	0	0	-1/16	0	0	0
11A1493	13/16	3/4	1	1 1/8	1	1 3/8
	-5/8	-5/8	-7/8	-1	-7/8	-1 5/16
11A1495	9/16	9/16	11/16	5/8	5/8	13/16
	-7/16	-1/2	-11/16	-9/16	-5/8	-13/16
			Site C			
11A1389	-5/8	-15/16	-1 3/16	5/16	3/8	5/8
	11/16	7/8	1 1/8	-5/16	-3/8	-9/16
13A1691	-5/8	-7/8	-1 5/16	1/8	0	1/8
	15/16	15/16	1 1/2	-1/8	1/16	-1/16
2A17	-13/16	-7/8	-1 9/16	-11/16	-1 3/8	-1 15/16
	13/16	1 1/16	1 5/8	3/4	1 3/8	2
44A3992	-15/16	-1 3/16	-1 1/16	-2 15/16	-3 15/16	-5 3/16
	1	1 1/4	1 13/16*	2 7/8	3 7/8	5 1/4
65B12	-3/8	-7/16	-7/16	-4 1/16	-5 3/4	-7 7/8
	-5/16	7/16	3/8	4 1/16	5 11/16	-7 15/16*
65B11	7/16	1/2	13/16	-4	-5 13/16	-7 5/16
	-9/16	-15/16	-1	3 13/16	5 1/16	7 3/8

Table B1. (Cont'd).

Support no.	ΔA, $\Delta A'$ (in.) Sept 1977	Mar 1978	Sept 1978	ΔB, $\Delta B'$ (in.) Sept 1977	Mar 1978	Sept 1978
44A3980	1/2	9/16	13/16	-2 7/16	-2 13/16	-4 1/8
	-5/8	-11/16	-15/16	2 3/8	2 7/16	4
2A202	0	-3/8	0	0	0	0
	-1/16	0	-1/16	0	0	0
13A2014	3/16	3/16	3/8	1/8	1/8	3/8
	-11/16	-11/16	-15/16	-1/4	-1/4	-1/2
Anchor	-3/16		1/8			
13A2016	-1/8	0	1/16	1/16	1/16	1/16
	1/8	0	-1/16	-1/16	-1/16	0
2A201	1/16	1/8	0	11/16	7/8	1 7/16
	0	0	0	-9/16	-3/4	-1 3/8
24A1268	3/16	-1/16	0	2	2 5/8	3 1/8
	-1/8	-1/4	-1/4	-2	-2 5/8	-3 1/8
2A204	7/16	1/2	5/8	2 3/8	3 5/16	4 1/8
	-3/8	-5/8	-5/8	-2 3/8	-3 3/8	-4 1/16
14A1760	3/8	7/16	1/2	1 3/8	1 3/4	2 3/16
	-1/4	-5/16	-7/16	-1 3/8	-1 3/4	-2 1/8
24A1266	1/8	3/16	5/8	-1/16	1/16	-7/16
	-1/16	-1/8	-7/16	1/16	1/16	1/2
43B3860	1/4	3/16	5/16	-1 5/16	-1 15/16	-3 1/2
	-1/16	-1/3	-1/16	1 3/8	2	3 5/8
46A4088	3/16	5/16	11/16	-3/8	-3/4	-3 9/16
	1 3/8	1 3/4	-7/8	3/8	3/4	4 1/2
52B123	1/16	1/8	9/16	-1 1/4	-1 1/4	-4 9/16
	-1/8	-1/8	-15/16	1 1/4	1 1/4	4 9/16
44A3982	3/16	1/8	7/16	-1 3/4	-1 3/4	-4 5/16
	1/16	1/16	-1/4	1 3/4	1 3/4	4 5/16
41B4111	5/16	1/2	13/16	-1 7/8	-2 3/8	-3 9/16
	-9/16	-9/16	-1 3/16	1 5/8	2 3/16	3 1/4
2A19	3/16	1/16	3/16	-1/8	-1/8	-1/8
	-3/16	-1/4	-1/4	1/16	0	0
13A2013	1/16	1/8	3/16	1 15/16	2 9/16	2 5/8
	-3/16	-3/8	-5/16	-1 15/16	-2 5/8	-2 5/8
2A73	0	1/8	1/16	2 7/8	4	4 1/16
	1/16	-1/16	-1/16	-2 3/4	-4	-3 15/16
2A75	5/8	7/8	1 1/8	1 13/16	2 7/16	2 3/4
	-1/2	-13/16	-7/8	-1 13/16	-2 7/16	-2 3/4
2A18	1/2	11/16	7/8	1/4	7/16	11/16
	-1/4	-3/8	-11/16	-3/16	-3/8	-3/4
23A1406	5/16	7/16	9/16	1/8	1/8	3/8
	-3/16	-5/16	-7/16	0	-1/8	-1/8
16A1450	-1/8	0	1/16	1/8	1/8	3/16
	1/16	-1/8	-1/8	1/16	1/8	1/8
13A2015		-1/16	-1/16		0	0
		0	0		5/16	5/16
14A1908		3/16	1/16		-1/16	-1/16
		-1/8	-1/16		3/8	3/8
14A1758		1/16	1/16		1/16	0
		1/16	0		0	-1/16
Anchor		1/8				
14A1906		-7/16	-11/16		-5/16	-1/4
		7/16	11/16		3/8	3/16
14A1907		-11/16	-7/8		-13/16	-1 1/8
		5/8	15/16		7/8	1 1/8

Table B1. (Cont'd).

Support no.	ΔA, ΔA' (in.) Sept 1977	ΔA, ΔA' (in.) Mar 1978	ΔA, ΔA' (in.) Sept 1978	ΔB, ΔB' (in.) Sept 1977	ΔB, ΔB' (in.) Mar 1978	ΔB, ΔB' (in.) Sept 1978
14A1905		-1/2	-13/16		-1 1/4	-1 7/16
		7/16	1/2		1 5/16	1 5/8
2A203		-9/16	-3/4		1/8	1/4
		3/8	9/16		-3/16	-3/8
35A0190		-13/16	-1 3/16		3 3/8	4 5/16
		9/16	1		-3 5/16	-4 7/16
53B86		-1 1/16	-1 1/2		6 3/8	7 11/16
		7/8	1 1/8		6 3/16	7 11/16
56A462		1 5/16	1 13/16		6 5/16	8 11/16*
		-1 5/16	-1 3/4		-6 1/4	-8 11/16
63B91		1 7/16	1 7/8		4 3/16	-6 3/4
		-1 1/4	-1 3/4		-4 3/16	6 3/4
53A411		1/16	1 5/8		2 1/2	4 3/8
		-1	-1 1/2		-2 3/8	-4 5/16
64B47		1 1/4	1 15/16*		1 11/16	2 3/4
		-1 1/4	-1 5/8		-1 3/4	-2 13/16
23A1405			1 1/4			3/16
			-1 3/16			-3/16

* Maximum displacement at each site.

Table B2. VSM tilt and changes in tilt.

First row: measurement C, D

Second row: measurement C', D'

Positive reading: Outward inclination perpendicular to pipeline. Downstream (relative to pipeline flow) inclination parallel to pipeline (see Fig. 2).

Support no.	Perpendicular to pipeline Tilt (°) Sept 77	Tilt (°) Sept 78	Tilt Change (°)	Parallel to pipeline Tilt (°) Sept 77	Tilt (°) Sept 78	Tilt Change (°)
			Site A			
33A3409	0.06	0.01	0.05	0.09	0	0.09
	-0.23	-0.24	0.01	-0.02	-0.02	0
7B141	-0.08	-0.05	0.03	-0.05	-0.10	0.05
	-0.45	-4.2	0.03	-0.71	-0.68	0.03
82A46	0	0.04	0.04	0.12	0.16	0.04
	0.03	-0.06	0.09	0.15	-0.06	0.21
62A178	0.75	0.75	0	0.12	0.30	0.18
	0.55	0.41	0.14	0.18	0.28	0.10
24A920	0.15	0.24	0.09	-0.31	-0.31	0
	-0.08	-0.06	0.02	0.09	0.05	0.04
11A1754	0.20	0.28	0.08	-0.60	-0.73	0.13
	-0.08	-0.08	0	0.43	0.43	0
			Site B			
22A90	-0.02	0.10	0.12	-0.02	0.07	0.09
	0.06	0.03	0.03	-0.11	-0.12	0.01
22A91	-0.05	-0.04	0.10	-0.02	-0.12	0.10
	0.06	0.24	0.18	-0.31	-0.19	0.12
23A193	0.04	0.16	0.12	0.03	0	0.03
	-0.20	-0.01	0.01	-0.02	0.03	0.05
23A195	-0.05	0.02	0.07	0	0	0
	-0.54	-0.49	0.05	0.06	0.14	0.08
43A0389	-0.11	-0.08	0.03	-0.02	0.03	0.05
	0.06	0.18	0.12	-0.17	-0.04	0.13
63B9	0.03	0.05	0.02	-0.02	0	0.02
	-0.37	-0.28	0.07	-0.34	-0.40	0.06
71A0265	0.04	0.18	0.14	-0.11	-0.10	0.01
	-0.11	-0.06	0.05	-0.40	-0.46	0.06
71B0889	-0.31	-0.18	0.13	-0.31	-0.36	0.05
	-0.40	-0.46	0.06	0.03	0.15	0.12
73A0448	0.38	0.40	0.02	0.09	0.16	0.07
	-0.11	-0.02	0.09	-0.08	0	0.08
62B5	-0.43	-0.41	0.02	-0.37	-0.28	0.09
	-0.34	-0.38	0.04	0.49	0.50	0.01
44A0460	-0.11	-0.16	0.05	-0.05	-0.02	0.03
	-0.02	-0.04	0.02	-0.08	-0.13	0.05
23A194	0	-0.10	0.10	0.03	-0.13	0.16
	-0.02	-0.01	0.01	0.18	0.20	0.02
15A1618	0.03	0.08	0.05	0.03	-0.20	0.23
	0	-0.01	0.01	0.03	0.30	0
25A93	-0.11	-0.09	0.02	-0.11	-0.14	0.03
	0	0.02	0.02	-0.20	-0.10	0.10
25A142	0.03	-0.09	0.12	0.03	0.33	0.30
	0	-0.14	0.14	-0.14	-0.10	0.04

Table B2. (Cont'd).

Support no.	Perpendicular to pipeline Tilt (°) Sept 77	Tilt (°) Sept 78	Tilt Change (°)	Parallel to pipeline Tilt (°) Sept 77	Tilt (°) Sept 78	Tilt Change (°)
15A1649	0.03	0.55	0.52	0.03	0.18	0.15
	0.12	0.33	0.21	-0.02	-0.20	0.18
Anchor						
			Site C			
21A115	-0.28	-0.12	0.16	-0.23	-0.28	0.05
	-0.11	-0.01	0.10	-0.45	-0.25	0.20
25A149	-0.02	0.15	0.17	-0.20	-0.02	0.18
	0	0.19	0.19	-0.11	-0.12	0.01
25A151	0	-0.01	0.01	0.03	0.15	0.12
	0.30	0.14	0.11	-0.14	-0.11	0.03
25A150	-0.23	-0.09	0.14	-0.23	-0.08	0.15
	-0.05	-0.04	0.01	0	0.03	0.03
25A152	-0.08	-0.02	0.06	-0.02	-0.06	0.04
	-0.05	-0.10	0.05	-0.63	-0.47	0.16
44A0446	0.03	0.15	0.12	-0.31	-0.16	0.15
	-0.20	-0.13	0.07	-0.11	-0.05	0.06
62B3	0.15	0.22	0.07	-0.23	0.02	0.25
	-0.14	-0.06	0.08	-0.02	0	0.02
72B0130	0.12	0.15	0.03	0	0.05	0.05
	-0.23	-0.18	0.05	-0.25	-0.25	0
74A0099	-0.05	0	0.05	0.03	0.05	0.02
	-0.08	0	0.08	0	0.10	0.10
72B0132	0.32	0.43	0.11	0.03	0.19	0.16
	-0.14	-0.09	0.05	-0.37	-0.35	0.02
55A57	0.03	0.13	0.10	0.03	0.24	0.21
	0.03	0.08	0.05	0.12	0.19	0.07
21A113	0.20	0.34	0.14	0.18	0.33	0.15
	0.32	0.45	0.13	-0.11	-0.28	0.17
11A129	-0.02	0.05	0.07	0.03	-0.07	0.10
	0.09	0.12	0.03	0.09	0.18	0.09
12A166	0.20	0.25	0.05	0.20	0.16	0.04
	0.12	0.26	0.14	0.06	0.27	0.21
12A168	-0.02	-0.20	0	-0.08	-0.07	0.01
	0.15	0.22	0.07	-0.11	0.06	0.17
Anchor						
			Site D			
14A1701		0.11			0.12	
		0.02			-0.18	
13A1739		-0.33			0.11	
		0.36			-0.24	
13A1871		0.21			0.09	
		0.17			-0.14	
23A1170		0.22			0.28	
		0.36			0.09	
24A757		-0.36			-0.29	
		0.06			-0.37	
24A726		0.24			0.12	
		0.49			-0.55	
24A798		0.53			0.03	
		0.05			0.03	
35A3498		-0.21			-0.23	
		-0.07			0.35	

Table B2. (Cont'd)

Support no.	Perpendicular to pipeline Tilt (°) Sept 77	Tilt (°) Sept 78	Tilt Change (°)	Parallel to pipeline Tilt (°) Sept 77	Tilt (°) Sept 78	Tilt Change (°)
52B126		-0.10			-0.22	
		0.05			0.16	
61B81		0.25			-0.60	
		0.05			-0.14	
73B0692		-0.07			-0.27	
		0.18			0	
52B125		-0.06			-0.14	
		0.15			0.22	
66A317		0.22			-0.11	
		0.22			0.34	
24A797		0.17			-0.06	
		0.27			0.03	
13A1872		-0.03			0.04	
		0.09			0.15	
15A1395		-0.05			-0.02	
		-0.03			0.10	
			Site E			
16A1393		0.10			0.20	
		-0.18			-0.09	
16A1396		0.12			0.30	
		-0.14			-0.49	
25A861		-0.13			-0.12	
		0.71			-0.18	
52A209		0.14			0.08	
		-0.10			-0.04	
76B0868		-0.15			-0.35	
		-0.20			-0.35	
76B0867		0.07			-0.62	
		-0.22			-0.08	
74A0880		-0.78			-0.36	
		0.80			0.15	
73B0850		-0.12			-0.03	
		-0.27			-0.07	
52A214		-0.05			0	
		0.18			-0.06	
34A2899		0.14			0.11	
		0.01			-0.07	
16A1394		0.12			-0.22	
		-0.05			-0.54	
Anchor						
23A1238		0.18			-0.34	
		-0.14			-0.20	
25A862		-0.18			0	
		-0.04			-0.51	
43B2346		-0.03			0.02	
		0.20			0.14	
42B0937		-0.03			-0.10	
		0.06			-0.06	
35A2920		0.40			0.04	
		-0.08			-0.51	
23A1237		-0.06			-0.33	
		0.06			0.13	
25A863		0.15			-0.15	
		-0.12			-0.26	

Table B2. (Cont'd).

Support no.	Perpendicular to pipeline Tilt (°) Sept 77	Perpendicular to pipeline Tilt (°) Sept 78	Perpendicular to pipeline Tilt Change (°)	Parallel to pipeline Tilt (°) Sept 77	Parallel to pipeline Tilt (°) Sept 73	Parallel to pipeline Tilt Change (°)
11A1450		0.41			0.57	
		-0.06			-0.56	
11A1452		-0.01			0.17	
		0.11			-0.33	
23A1240		-0.14			-0.15	
		0.29			-0.05	
24B72		0.11			-0.03	
		0.38			-1.0	
24B69		-0.08			0.08	
		0.05			0.27	
13A1560		0.17			0.16	
		-0.01			-0.14	
Anchor						
			Site F			
14A1574	-0.45	-0.43	0.02	-0.57	-0.55	0.02
	-0.31	-0.29	0.02	0.06	0.04	0.02
16A1411	-0.40	-0.39	0.01	0.03	0.05	0.02
	0.38	0.42	0.04	-0.71	-0.70	0.01
24B71	-0.45	-0.51	0.06	-0.20	-0.16	0.04
	-0.37	-0.39	0.02	-0.20	-0.17	0.03
21A696	-0.20	-0.18	0.02	-0.08	-0.19	0.11
	-0.14	-0.13	0.01	0.03	0.05	0.02
21A694	0	-0.05	0.05	0.26	0.27	0.01
	-0.11	-0.12	0.01	-0.02	-0.01	0.01
33B3585	0.23	0.29	0.06	0.15	0.16	0.01
	0.15	0.22	0.07	-0.43	-0.46	0.03
33A2860	-0.11	-0.12	0.01	-0.23	-0.09	0.14
	-0.17	0.03	0.20	-0.02	-0.08	0.06
43B0950	-0.08	-0.12	0.04	0.26	0.34	0.08
	-0.08	-0.09	0.01	-0.20	-0.34	0.14
33A2858	0.12	0.05	0.07	0	0	0
	-0.17	-0.12	0.05	0.46	0.38	0.08
33B3591	0.23	0.23	0	0.09	0.15	0.06
	0.09	0.05	0.04	-0.20	-0.24	0.04
22A701	0.26	0.27	0.01	0.09	0.01	0.08
	-0.14	-0.12	0.02	0.03	-0.04	0.07
21A693	0.15	0.05	0.10	-0.17	-0.26	0.09
	-0.08	-0.07	0.01	-0.14	-0.06	0.08
23B94	0.23	0.19	0.04	-0.17	-0.23	0.06
	-0.25	-0.25	0	-0.28	-0.32	0.04
16A1412	0.09	0.19	0.10	-0.14	-0.14	0
	0.12	0.12	0	0.03	-0.02	0.05
16A1409	0.37	0.52	0.15	0.23	0.22	0.01
	0.18	0.39	0.21	-0.60	-0.68	0.08
16A1410	0.46	0.57	0.11	-0.31	-0.36	0.05
	-0.40	-0.34	0.06	-0.20	-0.21	0.01
11A1494	0.32	0.40	0.08	-0.02	0.08	0.10
	0.46	0.51	0.05	-0.08	0.16	0.24
Anchor 11A1496	0.06	0.24	0.18	0.12	0.23	0.11
	-0.17	-0.16	0.01	-0.14	-0.27	0.13
21A695	-0.02	0.05	0.07	0.03	0.05	0.02
	0.20	0.29	0.09	-0.25	-0.40	0.15
33A2863	0.06	0.15	0.09	0.12	0.13	0.01
	0.26	0.19	0.07	-0.17	-0.32	0.15

Table B2. (Cont'd).

Support no.	Perpendicular to pipeline Tilt (°) Sept 77	Tilt (°) Sept 78	Tilt Change (°)	Parallel to pipeline Tilt (°) Sept 77	Tilt (°) Sept 78	Tilt Change (°)
53B221	-0.14	-0.27	0.13	0.29	0.20	0.09
	0.03	0.13	0.10	-0.23	-0.20	0.03
41B1248	-0.05	-0.24	0.19	0	-0.20	0.20
	0.03	0.05	0.02	-0.17	-0.09	0.08
31A2789	-0.23	-0.25	0.02	-0.08	-0.07	0.01
	-0.05	-0.07	0.02	-0.02	-0.04	0.02
22A702	0.26	0.35	0.09	-0.11	-0.05	0.06
	0.35	0.34	0.01	-0.28	-0.45	0.17
11A1493	0.03	-0.03	0.06	0.03	0.04	0.01
	0.20	0.16	0.04	-0.17	-0.24	0.07
11A1495	-0.25	-0.24	0.01	-1.17	-1.24	0.07
	0.03	0.06	0.03	-0.17	-0.20	0.03
			Site G			
11A1389	-0.23	-0.35	0.12	-0.40	-0.66	0.26
	-0.34	-0.30	0.04	0.12	0.14	0.02
13A1691	-0.25	-0.26	0.01	-0.28	-0.23	0.05
	-0.23	-0.29	0.06	0.38	0.21	0.17
2A17	-0.20	-0.40	0.20	0.43	0.68	0.25
	-0.25	-0.25	0	-0.48	-0.72	0.24
44A3992	-0.83	-0.78	0.05	0.41	0.48	0.07
	0.58	0.48	0.10	-0.28	-0.36	0.08
65B12	-0.40	-0.34	0.06	-0.63	-0.47	0.16
	-0.08	0	0.08	-0.77	-0.65	0.12
65B11	-0.08	0.05	0.13	-0.45	-0.47	0.02
	-0.80	-0.69	0.11	-0.05	-0.37	0.32
44A3980	-0.17	-0.24	0.07	-0.20	0.33	0.53
	-0.11	-0.08	0.03	0.06	0	0.06
2A202	0.15	0.14	0.01	-0.11	-0.13	0.02
	0.55	0.76	0.21	0.12	0.13	0.01
13A2014	-0.43	-0.56	0.13	-1.46	-1.42	0.04
	0.41	0.56	0.15	-0.51	-0.43	0.08
Anchor						
13A2016	-0.65	-0.44	0.21	-1.26	-1.33	0.07
	0.03	0.26	0.23	-0.05	0.06	0.11
2A201	-0.28	-0.26	0.02	-0.20	-0.09	0.11
	0.12	0.14	0.02	-0.48	-0.46	0.02
24A1268	-0.23	-0.13	0.10	-0.28	-0.21	0.07
	-1.54	-1.63	0.09	0.35	0.32	0.03
2A204	0.03	0.04	0.01	0.12	0.71	0.59
	0.66	0.25	0.41	-1.11	-1.13	0.02
14A1760	1.06	1.07	0.01	-1.06	-1.02	0.04
	1.49	1.40	0.09	0.98	0.94	0.04
24A1266	-1.49	-1.49	0	0.20	0.31	0.11
	-0.48	-0.77	0.29	-0.25	-0.28	0.03
43B3860	-0.25	-0.21	0.04	0.49	0.54	0.05
	-0.05	0.02	0.07	1.27	1.32	0.05
46A4088	0.72	0.80	0.08	-0.74	-0.63	0.11
	0.38	0.39	0.01	-0.05	0	0.05
52B123	0.20	0.22	0.02	0.66	0.77	0.11
	0.49	0.49	0	-0.17	-0.19	0.02
44A3982	-0.05	0	0.05	-0.05	0.20	0.25
	-0.20	-0.06	0.14	-0.31	-0.27	0.04
41B4111	-0.31	-0.17	0.14	-0.77	0.22	0.99
	0.18	-0.91	1.09	-0.20	0.08	0.28

Table B2. (Cont'd).

Support no.	Perpendicular to pipeline Tilt (°) Sept 77	Tilt (°) Sept 78	Tilt Change (°)	Parallel to pipeline Tilt (°) Sept 77	Tilt (°) Sept 78	Tilt Change (°)
2A19	0.12	0.26	0.14	-0.08	-0.03	0.05
	0.03	-0.06	0.09	-0.05	-0.49	0.44
13A2013	-0.25	-0.56	0.31	0.55	0.79	0.24
	0	0.25	0.25	-0.57	-0.44	0.13
2A73	-0.08	-0.06	0.02	0.26	0.43	0.17
	0.61	1.00	0.39	-0.40	-0.33	0.07
2A75	-0.11	-0.10	0.01	0.43	0.43	0
	-0.17	-0.12	0.05	-0.02	0.11	0.13
2A18	-0.31	-0.24	0.07	-0.34	-0.16	0.18
	-0.37	-0.33	0.04	-0.08	0.09	0.17
23A1406	-0.06	0.05	0.11	-0.65	-0.69	0.04
	-0.43	-0.41	0.02	-0.28	-0.15	0.13
16A1450	0.29	0.45	0.16	-1.06	-0.94	0.12
	0.92	0.93	0.01	-0.97	-0.94	0.03
14A1908		0.20			0.58	
		-0.52			-0.61	
13A2015		0.41			0.48	
		0.12			0	
14A1758		1.36			0.40	
		0.03			-0.84	
Anchor						
14A1906		0.39			0.08	
		0.44			-0.44	
14A1907		0.80			1.52	
		-0.20			0	
14A1905		-0.33			-0.17	
		0.65			-0.11	
2A203		0.31			-0.30	
		-0.07			-0.21	
35A0190		-0.01			1.18	
		-0.70			0.05	
53B85		-0.59			0.21	
		1.33			-1.61	
56A462		-0.29			-0.06	
		0.75			-0.33	
63B91		-0.28			0.16	
		-0.42			-0.10	
53A4111		0.07			-0.25	
		0.40			0.23	
64B47		0.13			0.49	
		-0.18			0.06	
23A1405		0.12			0.10	
		0.03			0	

Table B3. Changes in relative elevation of pipeline supports (as-built data from Alyeska Pipeline Service Co.).

Support no.	As-built elevation (ft)	Relative elevation (ft) As-built	Sept 1977	Sept 1978	Change in relative elevation (ft) Sept 77 to Sept 78	As-built to Sept 78
	Site A	Elevation relative to 33A3409 Survey Accuracy 0.03 ft				
Anchor						
33A3409	2495.89	0	0.01	0	-0.01	0
7B141	2495.74	-0.15	-0.14	-0.16	-0.02	-0.01
82A46	2495.58	-0.31	-0.29	-0.31	-0.02	0
5	2495.35	-0.54	-0.60	-0.62	-0.02	-0.08
6	2495.22	-0.67	-0.70	-0.71	-0.01	-0.04
7	2495.07	-0.82	-0.87	-0.89	-0.02	-0.07
8	2494.91	-0.98	-1.02	-1.04	-0.02	-0.06
9	2494.77	-1.12	-1.26	-1.28	-0.02	-0.17
10	2494.51	-1.74	-1.48	-1.51	-0.03	-0.23
11	2494.16	-1.73	-1.80	-1.84	-0.04	-0.12
12	2493.80	-2.09	-2.14	-2.19	-0.05	-0.10
13	2493.44	-2.45	-2.52	-2.58	-0.06	-0.13
14	2493.07	-2.81	-2.88	-2.91	-0.03	-0.09
15	2492.71	-3.18	-3.24	-3.28	-0.04	-0.10
16	2492.35	-3.54	-3.58	-3.60	-0.02	-0.06
17	2491.99	-3.90	-3.96	-3.97	-0.01	-0.07
18	2491.62	-4.27	-4.36	-4.36	0	-0.09
19	2491.27	-4.62	-4.72	-4.73	-0.01	-0.11
20	2490.91	-4.98	-5.04	-5.06	-0.02	-0.08
21	2490.10	-5.79	-5.88	-5.90	-0.02	-0.11
22	2488.78	-7.11	-7.14	-7.15	-0.01	-0.04
23	2487.46	-8.43	-8.52	-8.54	-0.02	-0.10
24	2486.07	-9.82	-9.96	-10.01	-0.05	-0.19
25	2484.45	-11.44	-11.52	-11.56	-0.04	-0.12
26	2482.92	-12.97	-13.10	-13.13	-0.03	-0.06
27	2482.43	-13.46	-13.54	-13.56	-0.02	-0.10
28	2482.87	-13.02	-13.11	-13.14	-0.02	-0.12
29	2483.29	-12.60	-12.70	-12.72	-0.02	-0.12
30	2483.74	-12.15	-12.25	-12.27	-0.02	-0.12
31	2484.20	-11.69	-11.77	-11.79	-0.02	-0.10
32	2484.64	-11.25	-11.36	-11.37	-0.01	-0.12
33	2486.97	-8.92	-8.93	-8.95	-0.02	-0.03
34	2493.07	-2.82	-2.96	-2.98	-0.02	-0.10
35	2501.61	5.72	5.60	5.58	-0.02	-0.12
36	2510.15	14.26	14.04	14.02	-0.02	-0.24
37	2520.38	24.49	24.28	24.25	-0.03	-0.24
62A178	2531.62	35.73	37.75	37.72	-0.03	1.99
24A920	2543.29	47.40	47.45	47.41	-0.04	0.01
11A1754	2549.98	54.09	54.42	54.36	-0.06	0.27
Anchor	2552.03					
	Site B	Elevation relative to 15A1649W Survey accuracy 0.02 ft (1977), 0.04 ft (1978)				
22A90	1952.30	-11.35	-11.70	-11.69	0.01	-0.34
22A91	1952.70	-10.95	-10.88	-10.88	0	0.07
23A193	1953.09	-10.56	-10.22	-10.22	0	0.34
23A195	1953.47	-10.18	-10.10	-10.09	0.01	0.09
43A0389	1953.85	-9.80	-9.82	-9.81	0.01	-0.01
63B9	1954.24	-9.41	-9.48	-9.44	0.04	-0.03
71A0265	1954.64	-9.01	-9.05	-9.05	0	-0.04

Table B3. (Cont'd).

Support no.	As-built elevation (ft)	Relative elevation (ft) As-built	Sept 1977	Sept 1978	Change in relative elevation (ft) Sept 77 to Sept 78	As-built to Sept 78
71B0889	1955.03	-8.62	-8.67	-8.68	-0.01	-0.06
73A0448	1955.44	-8.21	-8.27	-8.27	0	-0.06
62B5	1955.84	-7.81	-7.85	-7.85	0	-0.04
44A0460	1956.23	-7.42	-7.46	-7.46	0	-0.04
23A194	1957.21	-6.44	-6.48	-6.48	0	-0.04
15A1618	1958.77	-4.88	-4.87	-4.87	0	0.01
25A93	1960.40	-3.25	-3.26	-3.26	0	-0.01
23A142	1962.02	-1.63	-1.63	-1.62	0.01	0.01
15A1649 Anchor	1963.65	0	0	0	0	0
	Site C	Elevation relative to 21A115W Survey accuracy 0.02 ft				
21A115	1153.73	0		-0.04		-0.04
25A149	1159.63	5.90		5.90		0
25A151	1161.26	7.53		7.53		0
25A150	1158.46	4.73		4.97		0.24
25A152	1155.74	2.01		2.01		0
44A0446	1152.22	-1.51		-1.51		0
62[illegible]3	1147.89	-5.84		-5.86		-0.02
72B0130	1143.45	-10.28		-10.29		-0.01
74A0099	1143.49	-10.24		-9.91		0.33
72B0132	1148.05	-5.68		-5.69		-0.01
55A57	1152.49	-1.24		-1.26		-0.02
21A113	1156.91	3.18		3.16		0.02
11A129	1161.36	7.63		7.59		0.04
12A166	1165.89	12.16		12.14		0.02
12A168 Anchor	1170.43	16.70		16.70		0
	Site D	Elevation relative to 15A1395 Survey accuracy 0.06 ft				
15A1395	927.93	0		-0.01		-0.01
13A1872	916.83	-11.10		-11.12		-0.02
24A797	906.28	-21.65		-21.71		-0.06
66A317	896.28	-31.65		-31.68		-0.03
52B125	886.83	-41.10		-41.13		-0.03
73B0692	876.83	-51.10		-51.15		-0.05
61B81	866.87	-61.06		-61.10		-0.04
52B126	856.92	-71.01		-71.04		-0.03
35A3489	847.43	-80.50		-80.56		-0.06
24A798	838.31	-89.62		-89.67		-0.05
24A726	829.51	-98.42		-98.48		-0.06
24A757	820.24	-107.69		-107.75		-0.06
23A1170	814.71	-113.22		-113.28		-0.06
13A1871	809.79	-118.14		-118.17		-0.03
13A1739	801.67	-126.26		-125.96		-0.30
14A1701 Anchor	797.62	-130.31		-130.33		-0.02
	Site E	Elevation relative to 12A1560 Survey accuracy 0.002 ft				
16A1393	466.69	10.28		10.51		-0.23
16A1396	466.84	10.13		10.00		0.13

Table B3. (Cont'd).

Support no.	As-built elevation (ft)	Relative elevation (ft) As-built	Relative elevation (ft) Sept 1977	Relative elevation (ft) Sept 1978	Change in relative elevation (ft) Sept 77 to Sept 78	Change in relative elevation (ft) As-built to Sept 78
25A861	466.98	9.99		9.74		0.25
52A209	467.11	9.86		9.60		0.26
76B0868	467.25	9.72		9.69		0.03
76B0867	467.39	9.58		9.59		-0.01
74A0880	467.54	9.43		9.44		-0.01
73B0850	467.68	9.29		9.29		0
52A214	467.82	9.15		9.15		0
34A2899	467.95	9.02		9.02		0
16A1394	468.10	8.87		8.88		-0.01
Anchor						
23A1238	468.38	8.59		8.59		0
25A862	468.53	8.44		8.45		-0.01
43B2346	468.82	8.15		8.15		0
42B0937	469.29	7.68		7.70		-0.02
35A2920	469.69	7.28		7.28		0
23A1237	470.13	6.84		6.84		0
25A863	470.56	6.41		6.39		0.02
11A1450	471.00	5.97		5.97		0
11A1452	471.43	5.54		5.55		-0.01
23A1240	472.58	4.39		4.40		-0.01
24B72	474.46	2.51		2.51		0
24B69	476.37	0.60		0.58		0.02
13A1560	476.97	0		0		0
Anchor						
	Site F	Elevation relative to 14A1574 Survey accuracy 0.01 ft				
14A1574	519.13	0		0		0
16A1411	518.58	-0.55		-0.53		0.02
24B71	518.04	-1.09		-1.09		0
21A696	517.51	-1.62		-1.60		0.02
21A694	516.96	-2.17		-2.17		0
33B3585	516.43	-2.70		-2.72		-0.02
33A2860	515.99	-3.14		-3.18		-0.04
43B0950	515.77	-3.36		-3.37		-0.01
33A2858	515.78	-3.35		-3.37		-0.02
33B3591	516.00	-3.13		-3.16		-0.03
22A701	516.34	-2.79		-2.88		-0.09
21A693	516.69	-2.44		-2.44		0
23B94	517.99	-1.14		-1.17		-0.03
16A1412	520.26	1.13		1.16		0.03
16A1409	522.53	3.40		3.26		-0.14
16A1410	524.81	5.68		5.67		-0.01
11A1494	527.08	7.95		7.93		-0.02
Anchor						
11A1496	531.46	12.33		12.30		-0.03
21A695	533.72	14.59		14.56		-0.03
33A2863	537.37	18.24		18.21		-0.03
53B221	542.42	23.29		23.23		-0.06
41B1248	547.14	28.01		27.91		-0.10
31A2789	552.19	33.06		32.93		-0.03
22A702	557.23	38.10		38.05		-0.05
11A1493	562.27	43.14		43.08		-0.06
11A1495	566.99	47.86		48.56		-0.30

Table B3. (Cont'd).

Support no.	As-built elevation (ft)	Relative elevation (ft) As-built	Relative elevation (ft) Sept 1977	Relative elevation (ft) Sept 1978	Change in relative elevation (ft) Sept 77 to Sept 78	Change in relative elevation (ft) As-built to Sept 78
	Site G	Elevation relative to 11A1389 Survey accuracy 0.02 ft				
11A1389	697.39	0		0.01		
13A1691	697.09	-0.30		-0.30		0
2A17	696.79	-0.60		-0.51		0.09
44A399A	696.49	-0.90		-0.79		0.11
65B12	696.19	-1.20		-1.08		0.12
65B11	695.88	-1.51		-1.58		-0.07
44A3980	695.59	-1.80		-1.79		0.01
2A202	695.29	-2.10		-2.08		0.02
13A2014	694.99	-2.40		-2.37		0.03
Anchor						
13A2016	694.38	-3.01		-2.93		0.08
2A201	694.07	-3.32		-3.26		0.06
24A1268	693.78	-3.61		-3.49		0.12
2A204	693.86	-3.53		-3.45		0.08
14A1760	693.94	-3.45		-3.38		0.07
24A1266	694.04	-3.35		-3.28		0.07
43B3860	694.12	-3.27		-3.20		0.07
46A4088	694.20	-3.19		-3.13		0.06
52B123	694.30	-3.09		-3.02		0.07
44A3982	694.38	-3.01		-2.94		0.07
41B4111	694.47	-2.92		-2.88		0.04
2A19	694.56	-2.83		-2.78		0.05
13A2013	694.65	-2.74		-2.67		0.07
2A73	694.74	-2.65		-2.56		0.09
2A75	694.83	-2.56		-2.49		0.07
2A18	694.93	-2.46		-3.05		-0.59
23A1406	688.84	-8.55		-8.50		0.05
16A1450	686.55	-10.84		-10.92		-0.08
	Site G	Elevation relative to 13A2015 Survey accuracy 0.01 ft				
13A2015	686.55	0		-0.01		
14A1908	688.48	1.93		1.94		0.01
14A1758	695.61	9.06		9.08		0.02
Anchor						
14A1906	695.85	9.30		9.34		0.04
14A1907	695.95	9.40		9.38		-0.02
14A1905	696.06	9.51		9.51		0
2A203	696.17	9.62		9.64		0.02
35A0190	696.27	9.72		9.73		0.01
53B86	696.38	9.83		9.88		0.05
56A462	696.47	9.92		9.95		0.03
63B91	696.25	9.70		6.81		-2.89
53A411	696.02	9.47		9.51		0.04
64B47	695.78	9.23		9.26		0.03
	Site H	Elevation relative to 13A2139 Survey accuracy 0.02 ft				
Anchor						
13A2139	914.11	0		-0.01		-0.01
11A1824	912.74	-1.37		-1.35		0.02

Table B3. (Cont'd).

Support no.	As-built elevation (ft)	Relative elevation (ft) As built	Sept 1977	Sept 1978	Change in relative elevation (ft) Sept 77 to Sept 78	As-built to Sept 78
11A1823	911.36	-2.75		-2.74		0.01
2A124	909.94	-4.17		-4.17		0
35A4075	906.79	-7.32		-7.32		0
53B252	901.85	-12.26		-12.22		0.04
54B191	897.18	-16.93		-16.90		0.03
34A4057	892.29	-21.82		-21.87		0.05
23A1341	881.53	-32.58		-32.05		0.53
11A1822	866.64	-47.47		-47.43		0.04
11A1821	852.36	-61.75		-61.74		0.01

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Movement study of the Trans-Alaska Pipeline at selected sites / by H.T. Ueda, D.E. Garfield and F.D. Haynes. Hanover, N.H.: U.S. Cold Regions Research and Engineering Laboratory; Springfield, Va.: available from National Technical Information Service, 1981.
iv, 40 p., illus.; 28 cm. (CRREL Report 81-4.)
Prepared for U.S.A. Facilities Engineer Support Agency by Corps of Engineers, U.S. Army Cold Regions Research and Engineering Laboratory.
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